satisfaction, with the institutional stay of some patients materially shortened, others saved from a deforming thoracoplasty, and possibly some from a down-hill course. And, in the organization that gives free treatment to all the tuberculous residents of the province, the cost of equipment has already been repaid in decreased treatment days and in removing the necessity for more expensive surgical work.

This article presents little that is new, but a compilation of the information herein would have obviated months of delay and have been a great help to us in taking our first steps. It is hoped that the account of the experience of one organization in inaugurating the use of this necessary adjunct to collapse treatment will be of assistance to others who may be planning to become equipped and undertake the work.

Our thanks are due to the men mentioned and to others, masters of the art, for information and advice so readily given; and to Dr. R. G. Ferguson, Director of Medical Services of the League, for his encouragement and for securing the necessary equipment.

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FIRST STEPS IN PNEUMOLYSIS[1]

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Closed intrapleural pneumolysis, introduced by Jacobaeus of Stockholm in 1913, is now in an established position as a valuable aid in the collapse treatment of pulmonary tuberculosis. Along with artificial pneumothorax, phrenic-nerve interruption, and thoracoplasty, the cutting of pleural adhesions must be available when indicated if the best is to be secured from a program of collapse therapy.

While many sanatoria and tuberculosis clinics are not equipped, as yet, to do this work, it was thought that a record of the experience of introducing the procedure in the group of three sanatoria operated by the Saskatchewan Anti-Tuberculosis League would be of interest.

All pneumothorax workers are familiar with the high percentage of cases in which adhesions prevent satisfactory therapeutic collapse. In a substantial proportion of these cases this can be secured by severing the adhesions.

Closed intrapleural pneumolysis, as may seem unnecessary to state, consists of introducing, under local anaesthesia, two cannulae into the pneumothorax space, inserting an electrically lighted thoracoscope through one opening and a cutting instrument, either cautery or electrosurgical, through the other. Then, under visual control, the adhesion is severed by one or the other of these "bloodless" methods. The details of the technique need not be given here. They can readily be found in numerous articles in the literature of tuberculosis and thoracic surgery. Judging from perusal of a preliminary draft, Matson's section in Graham, Singer and Ballon's *Surgical Diseases of the Chest*, recently issued by Lea & Febiger, is the most comprehensive treatise on the subject yet published.

While this closed intrapleural or internal operation by puncture of the chest-wall appears to be the one of choice, it is interesting to note that in some quarters the previously discarded method of external operation through an open incision in the chest-wall has been revived with improved technique and very satisfactory results.

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Our first contact with internal pneumolysis, other than through the literature, was in the winter of 1930–1931 at the City of London Hospital for Diseases of the Heart and Lungs, Victoria Park. Here were observed several operations performed by Dr. F. G. Chandler, who was extremely kind in demonstrating his technique and furnishing a great deal of information regarding the problems involved. This internist asserted that the procedure need not be left to the thoracic surgeon but could be carried out quite satisfactorily by physicians familiar with tuberculosis and artificial pneumothorax.

On returning from England, an opportunity occurred to visit Dr. Ralph C. Matson of Portland, Oregon, who has done much to popularize the operation on this continent. This thoracic surgeon was very kind in demonstrating his equipment and discussing the procedure. Unfortunately, no operative work was done during the short stay in Portland. Dr. Matson also offered encouragement to attempt the work.

After this visit the decision was made to get Matson's instruments and an electrosurgical unit made on this side of the Atlantic. The greater difficulty in obtaining service and replacements weighed rather heavily in the decision against the English equipment, which is excellently made and has some points in its favor, as, for example, it can be sterilized by boiling as Matson's cannot.

For the actual cutting two means are available,—the original cautery of Jacobaeus, and the electrosurgical method introduced, we believe, by Matson. The latter technique is considered by most operators to be the safer and permits of more extensive work being done as the operator's experience and expertness increase. However, quite extensive folds have been severed successfully with the "cold" cautery, and some who have both available prefer this method for string and small cord adhesions. Maurer, in Switzerland, combines the two, coagulating first and then cutting with the electrocautery.

The relative cost of the equipment necessary for these two methods has considerable to do with the decision of which to use. A cautery set can be obtained for about $200.00, while the electrosurgical equipment with one thoracoscope and necessary accessories costs $700.00 or more, depending principally on the surgical diathermy unit included.

Fortunately the way was opened to install the latter and the following items were secured: Matson's trocar and bakelite cannulae, and electrodes (made by McKissick, Portland), Jacobaeus-Unverricht indirect 90°-vision thoracoscope (Wolf), Bethune's transilluminator (Pilling), a formalin vapor sterilizer and a portable surgical diathermy apparatus (Mobile Bovie unit, Liebel-Flarsheim) capable of giving suitable coagulating and cutting currents. Later it is hoped to add a Kremer direct-vision telescope, and an intrathoracic haemostat with insulated shaft, which may be inserted through the cannula and connected with the diathermy unit for coagulating tissue within the instrument's jaws. All this equipment is readily shipped from one institution to another.

The bakelite cannulae have an advantage over metal ones, either rigid or flexible, in that they furnish additional insulation, practically removing the possibility of a short circuit to the chest-wall with resulting burns. They, however, do not permit the use of an electrode with a curved shaft such as is included in most sets, but one of Matson's electrodes may be curved and another angled after insertion through the cannula, by turning a fluted segment of the handle, thus giving the advantages of both the straight and curved instruments. These electrodes have extensions which may be fitted between the shaft and point, and are supplied with ball, needle, and blade tips which are interchangeable.

What is considered a minor improvement to this adjustable curve electrode was made by continuing down to the tip the white line on the handle which indicates the direction of curve. By seeing this line as the instrument is being manipulated within the chest, the operator, without removing his eye from the thoracoscope, is assured of the direction the tip will move and of the plane the curve to be formed in the shaft will take. The adjustable angle instrument, while somewhat more convenient to use, has the disadvantage that its joint is not insulated. This makes it necessary for the operator ever to be on the alert to see that this joint is not in contact with tissue when the current is flowing. Such contact might easily result in serious damage being done.

The Jacobaeus-Unverricht indirect thoracoscope with the line of vision at right angles to the shaft was selected as giving the best visual field and being the most useful all-around instrument if only one was to be used. In observing work being done elsewhere with the direct-vision telescope alone, it appeared that to secure suitable intrathoracic relations of the optical and cutting instruments to each other and to the adhesions, especially to those at the more common sites, it was necessary to place the two cannulae and instruments in positions that seemed to be very awkward for the operator. Consequently the subsequent manipulations were more difficult. However, the direct instrument is more convenient in some cases; having both is preferable.

It appeared that there was a defect in the usual technique in that the eyepiece of the thoracoscope and the fingers holding it easily came in contact with the operator's eyebrow, an unsterile area. This defect was overcome by the wearing of sterilized large-lens glasses and a mask which covered the entire face except for a narrow horizontal slit across the eyes. Chance contact is thus prevented. No evidence is offered that this precaution is necessary.

The transilluminator devised by Dr. Norman Bethune of Montreal has proved to be very useful. While having a curved shaft the diameter is so small that it can be used through Matson's straight bakelite cannulae. By placing a light behind an adhesion and observing with the unlighted thoracoscope it is possible to get a much better idea of its thickness and whether or not it contains blood-vessels or lung tissue than can be obtained with the thoracoscope alone. Current for both the transilluminator and the thoracoscope is obtained from an adjustable two-cell battery unit of flash-light size (Boehm).

The formalin vapor sterilizer, such as is used for catheters and urological instruments, was included, as the electrodes and optical unit cannot be boiled. The time required to carry out this method of sterilization is a disadvantage, especially when doing work in different institutions. Only two operations can be performed a day, one in the early morning and one in the late afternoon or evening.

Various standard surgical diathermy units have been used for adhesion cutting and have been reported as satisfactory. Apparently any good one will do, provided the high-frequency current delivered is not a pure cutting current, that is, continous and undamped. Matson urges the use of the Davis-Bovie instrument on account of the variable damping feature obtainable with this machine. With this a cutting current of any selected strength may be damped at three different settings, thus incorporating light, medium, or heavy degrees of coagulating power with the cutting current for the simultaneous dehydration and sealing of the tissue at the edges as the cut is being made. Our small mobile Bovie unit does not have this desirable feature, but delivers a cutting current somewhat damped, resulting in moderate concurrent haemostatic action.

It seems impractical to have the operator control the machine when so many other things are demanding his attention at the time. Notwithstanding the sterilizable handles supplied on many machines for current selection and power control, it is better to have a technician present for this purpose, an a foot-switch, preferably with a single treadle, for the operator is an almost necessary accessory. A small shaded desk-light under the technician's control is convenient, and gives sufficient illumination when any is required in the dark operating room.

The various operating thoracoscopes with which the operation is done through one hole in the chest were not considered. Most authorities agree that the patient tolerates two punctures as well as one, and the two-hole method, using straight cannulae, has the added advantage that the instruments may be interchanged in the cannulae, which often gives a better view or easier access to an adhesion than that secured at first. These complicated combined viewing and operating instruments appear to be used more extensively by their inventors than by others.

Anaesthetizing the costal attachment of the adhesion before cutting is another point where practice and equipment differs. At Victoria Park London, this is done almost routinely through the cannulae with an especially designed long needle adapter or a direct-vision telescope which delivers the local anaesthetic through a needle at its tip. On the other hand, Matson states that he has never felt any need for this anaesthesia. In some quarters it is secured by externally blocking the nerves to the area in the intercostal spaces near the vertebrae. Neither method has been used here and pain has not been a troublesome feature.

One more point regarding equipment. There does not appear much need for having instruments which make an air-tight fit with the cannulae. With Matson's set there is free communication between the pleural space and the atmospheric air throughout the operation. No ill effects have been observed from this even in patients with mediastinal herniae, and in those with contralateral pneumothorax. The completely closed technique attempting to maintain the existing intrathoracic pressure does not appear necessary, and the inability to increase pressure during the operation has not been a disadvantage. Smoke produced by cutting has given no trouble and its removal has not been needed.

After securing the equipment the next step was to become familiar with the coagulating and cutting currents produced by the electrosurgical unit. This was done first on meat and then on anaesthetized animals. The effect of currents of different strengths, on different tissues, with the ball, point, and blade electrodes, and with these being moved at different speeds, was studied.

At the same time, practice of the bimanual manipulation of the thoracoscope and electrode was being carried on. This was done on a dummy chest constructed on a skeleton. A cardboard partition was fixed in place to represent the mediastinum. Hooks were placed on this at the approximate position of the lung roots, and elastic bands were stretched from these to various parts of the thoracic cage to represent adhesions. The thorax was covered with $\frac{1}{4}$-inch felt, closely fitted and sewn in place. A diaphragm of felt was also fastened in position. With the felt over the ribs the cannulae were held in place very much as in the living subject. Invaluable practice was obtained in orientation within the thorax with the 90°-vision instrument from various points of entry.

Even more helpful was the development of ability to place the tip of the electrode quickly and surely where it was wanted while guiding it under thoracoscopic vision. It took considerable practice at this to become reasonably expert. The chief difficulty lies in the fact that the line of vision is at right angles to the direction in which the operator is looking, and the electrode must be moved by the hand in a different direction than that which appears to the eye to be the right one.

This form of dummy chest would seem to furnish as good, if not better, practice than the elaborate ones supplied by instrument makers. The advantage of stringing within a dummy chest strips of meat to represent adhesions is not apparent if the cutting experience is obtained on meat and animals and the manipulative technique is developed on the dummy.

With this background operative work was essayed. To date, operations have been attempted on 22 patients. As yet the one operator is doing the work in all three sanatoria.

The results have been very satisfactory, about 60 per cent having been clinically successful. In several, the operation resulted in obliteration of large cavities which had shown no tendency to close under pneumothorax. In two of them the two-stage procedure was carried out. In this, at the first operation, an adhesion too large and short to cut safely was encircled near its costal attachment by a zone of coagulation and was found some weeks later to be stretched out into a relatively thin band which was easily cut.

In several cases what appeared to be strings on the X-ray films turned out to be the edges of broad spool or fold adhesions too large to cut. This bears out the statement of most writers that adhesions are usually more numerous and extensive and the operation more difficult than the preliminary X-ray study suggests. In some of the attempted cases no benefit was derived by the patient; what cutting it was thought could be done safely did not free the lung. Probably, with more experience and less timidity on the operator's part, more of this group could have been successfully operated upon.

The occurrence of operative and postoperative complications has not been unduly frequent. Subcutaneous emphysema was quite extensive in three of the early cases. Several developed effusion which followed the usual benign course of fluid complicating artificial pneumothorax. In one case an existing effusion became a sterile empyema. Haemorrhage from the costal stump was encountered twice but was readily controlled by deep coagulation. One patient with extensive disease (a large cavity and bilateral pneumothorax) developed, shortly afterward, an acute spread on the opposite side; possibly this should be attributed to the operation.

The series of cases has been small as a very conservative attitude has been adopted in accepting indications for operation. It was considered that adhesions should be holding diseased areas uncollapsed or cavities open and the patient have a positive sputum before cutting should be attempted. Also, reasonable hope should exist that the adhesion could be safely cut and the operation result in a therapeutic collapse being obtained. Often the former point can only be settled after the thoracoscopic study.

Operation has not been attempted in all cases presenting apparently cutable adhesions on the X-ray film. The argument is used that any resulting increase in collapse ensures a more solid fibrosis and a safer healed lesion in the end. This may be so, but, as yet, adhesions without the foregoing definite indications for cutting have been left alone, no matter how inviting they appeared to the operator.

Without minimizing the difficulties and dangers involved, closed intrapleural pneumolysis appears to be an operative procedure well within the abilities of most physicians working in tuberculosis. It is difficult to see where experience in general surgery, or even thoracic surgery, would be of much help, as the technique of this work is so radically different. Familiarity with using the cystoscope with its similiar indirect field of vision would be of some assistance, and experience with electrosurgical technique would be valuable. Otherwise, a knowledge of pulmonary tuberculosis and pneumothorax therapy, a mechanical turn of mind, and good manual dexterity are the main requirements.

Developing this work without special training under an expert has been most interesting and instructive. The results have been a source of